Fruit Ripening and Quality Relationships

Informal polling via ‘Socrative’

- Download the ‘Socrative’ app on your phone (Socrative for student), or connect via the website (www.socrative.com)
- Join (as a student) with the room code: FRUITRIPENING
- You will be able to answer “quiz” questions via this interface.

Stages of Fruit Development

- INITIATION
- DEVELOPMENT
- DEATH
- GROWTH
- MATURATION
- PHYSIOLOGICAL MATURITY
- RIPENING
- SENESCENCE

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John O'Neill
Stages of Fruit Development

Development
- The series of processes from the initiation of growth to death of a plant or plant part.

Growth
- The irreversible increase in physical attributes (characteristics) of a developing plant or plant part.

Stages of Fruit Development

Ripening
- The set of processes that occur from the later stages of growth through the early stages of senescence and that results in characteristic aesthetic and/or eating quality, as evidenced by changes in composition, color, texture, or other sensory attributes.

Stages of Fruit Development

Maturation
- The stage of development leading to the attainment of physiological or horticultural maturity

Physiological maturity
- The stage when a plant or plant part will continue developing even if detached

Horticultural maturity
- The stage of development when a plant or plant part possesses the prerequisites for utilization by consumers

Stages of Fruit Development

CO₂

Calvin Cycle
Sugars
Glycolysis
Volatiles
Pigments
Proteins
More carb.
Acids
Sugars

John O'Neill
**Physiological Changes Accompanying Senescence of Horticultural Crops**

**Cellular:**
- Loss of chlorophyll, disassembly of chloroplast structure
- Degradation of cell walls
- Altered membrane composition, loss of fluidity
- Loss of cellular compartmentation, release of vacuolar contents

**Senescence**
- The last stage of development during which degradation of biological components occur.

**Physical Changes Accompanying Senescence of Horticultural Crops**

**Color:**
- Loss of green color
- Synthesis of new pigments (carotenoids, flavonoids)

**Texture:**
- Softening
- Wilting
- Drying

**Loss of resistance to pathogens:**
- Development of infections
- Lesions

**Respiration and ethylene production rates of climacteric and non-climacteric fruits**

**Composition:**
- Altered sugar content, and switch to alternative substrates for respiration
- Net loss of RNA
- Increased protease activity, net loss of protein
- Altered amino acid content
**Maturity and Ripening**

**Group 1:** Fruits that are not capable of continuing their ripening process once removed from the plant.

<table>
<thead>
<tr>
<th>Blackberry</th>
<th>Loquat</th>
<th>Pomegranate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cherry</td>
<td>Lychee</td>
<td>Prickly pear</td>
</tr>
<tr>
<td>Grape</td>
<td>Mandarin</td>
<td>Rambutan</td>
</tr>
<tr>
<td>Grapefruit</td>
<td>Muskmelons</td>
<td>Raspberry</td>
</tr>
<tr>
<td>Lemon</td>
<td>Orange</td>
<td>Strawberry</td>
</tr>
<tr>
<td>Lime</td>
<td>Pepper (bell)</td>
<td>Tamarillo</td>
</tr>
<tr>
<td>Longan</td>
<td>Pineapple</td>
<td>Watermelon</td>
</tr>
</tbody>
</table>

**California Minimum Maturity Indices for Selected Non-Climacteric Fruits**

<table>
<thead>
<tr>
<th>Fruit</th>
<th>Minimum maturity indices</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pomegranate</td>
<td>Red juice color and below 1.85% acid in juice</td>
</tr>
<tr>
<td>Grape</td>
<td>14 to 17.5% SS (depending on cultivar and production area) or a SS/A ratio of 20 or higher</td>
</tr>
<tr>
<td>Strawberry</td>
<td>&gt;3/4 of fruit surface showing a pink or red color</td>
</tr>
</tbody>
</table>

**Maturity and Ripening**

**Group 2:** Fruits that can be harvested before fully ripe, and ripened off the plant.

<table>
<thead>
<tr>
<th>Apple</th>
<th>Mango</th>
<th>Persimmon</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apricot</td>
<td>Nectarine</td>
<td>Plum</td>
</tr>
<tr>
<td>Avocado</td>
<td>Papaya</td>
<td>Quince</td>
</tr>
<tr>
<td>Banana</td>
<td>Passion fruit</td>
<td>Sapodilla</td>
</tr>
<tr>
<td>Cherimoya</td>
<td>Peach</td>
<td>Sapote</td>
</tr>
<tr>
<td>Guava</td>
<td>Pear</td>
<td>Tomato</td>
</tr>
<tr>
<td>Kiwifruit</td>
<td>Pepper (chili)</td>
<td></td>
</tr>
</tbody>
</table>

**California Minimum Maturity Indices for Pome Fruits**

<table>
<thead>
<tr>
<th>Fruit</th>
<th>Minimum maturity indices</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apple</td>
<td>Starch pattern, above 10.5 to 12.5% SS and below 18 to 23 lb-force firmness (depending on cultivar)</td>
</tr>
<tr>
<td>Pear (Bartlett)</td>
<td>Yellowish-green color, and/or below 23 lb-force firmness, and/or above 13% SS</td>
</tr>
<tr>
<td>Persimmon</td>
<td>Yellowish-green to orange color (depending on cultivar)</td>
</tr>
</tbody>
</table>

SS = soluble solids
Quality Attributes of Fruits

- Vary depending on protagonist in PH chain
- Consumer-centric “quality” ultimately drives marketability and sales
- Overall consumer acceptance strongly correlated with “Flavor acceptance”

Perception of Quality

- Our sensory systems are responsible for generating an internal representation of the outside world, including its chemical (taste and olfaction) and physical (mechanical, sound, vision and temperature) features.
- When evaluating the quality of the foods we eat, we use the complete array of our sensory system (chemical and physical senses) and integrate this information to formulate a judgment.

Sensory Attributes of Foods

- Appearance
- Taste
- Odor/smell/aroma
- Irritation/pain
- Texture/mouthfeel
- Temperature

Flavor

Appearance

- First attributes perceived
- Shape
- Color
  - Strongly-set expectations
  - Emotional connotations
Sensory Attributes of Foods

**Taste**

- Our sense of **taste** is in charge of evaluating the nutritious content of food and preventing the ingestion of toxic substances.
- Taste is a sensation perceived **in the mouth**, more specifically **on the tongue**.

- Sweet
- Salty
- Bitter
- Sour (acidic)
- Umami (protein – savory)

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**Are taste preferences innate or learned?**

- **A. Innate** (= we are born preferring sweet/salty/umami tastes)
- **B. Learned** (= as we grow up, we learn to prefer sweet/salty/umami tastes)

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**Fruit Composition and Taste**

<table>
<thead>
<tr>
<th>Quality</th>
<th>Class of compound</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sweet</td>
<td>Sugars</td>
<td>Sucrose, fructose, glucose</td>
</tr>
<tr>
<td>Sour</td>
<td>Acids</td>
<td>Citric acid, malic acid, tartaric acid</td>
</tr>
<tr>
<td>Bitter</td>
<td>Alkaloids, Phenolics, Terpenoids, some proteins</td>
<td>Naringin, cucurbitacins, limonoids</td>
</tr>
<tr>
<td>Salty</td>
<td>Ions</td>
<td>Sodium, calcium</td>
</tr>
<tr>
<td>Umami</td>
<td>Amino acids</td>
<td>Glutamate, aspartate</td>
</tr>
</tbody>
</table>

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**Taste vs. Sugar/Acid Ratio**

<table>
<thead>
<tr>
<th>Acids</th>
<th>Sugars</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>Low</td>
<td>Insipid, tasteless</td>
</tr>
<tr>
<td>Moderate to High</td>
<td>Sour, tart</td>
</tr>
</tbody>
</table>

**Need quick methods of measuring total sugars and titratable acidity**

Soluble solids measured by a refractometer = sugars, organic acids, soluble pectins, anthocyanins, phenolic compounds, ascorbic acid...
Aroma (or smell or odor) is the sensation perceived when volatile compounds are drawn into the nose.

**Sensory Attributes of Foods**

**Aroma**

- **Innate** (we are born preferring/rejecting certain smells)
- **Learned** (as we grow up, we learn to prefer/reject certain smells)

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**Are smell/scent preferences innate or learned?**

A. **Innate** (we are born preferring/rejecting certain smells)
B. **Learned** (as we grow up, we learn to prefer/reject certain smells)

**Sensory Attributes of Foods**

**Texture / Mouthfeel**

- Astringency (tannins, calcium oxalate)
- Sense of touch (mechanoreceptors)

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**The Aroma of a Strawberry**

Over 200 volatile compounds !!

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Guinard, 2005
Sensory Attributes and Fruit Composition

- All fruit components (sugars, acids, volatiles, etc...) combine to generate a unique sensory experience for the consumer.

- Physical methods can give accurate measurements of fruit composition but it is difficult to relate these measurements to fruit quality without information about sensory perception.

Sensory Methodology

- **Analytical tests**
  - Difference? What is it? How strong is it?
  - Descriptive analysis
  - Trained judges

- **Consumer tests**
  - Preference, liking, purchase intent
  - Attitudes, beliefs
  - Ethnography
  - Untrained consumers

Objective measurements and Quality prediction

- Development on the plant
  - Developmental program
  - Physiological processes (metabolism)
  - Changes in composition
  - Genetic/environmental/cultivation factors
  - Harvesting at maximum potential

- Postharvest Life (?)
  - Altered physiological processes (metabolism)
  - Changes in composition
  - Genetic/environmental/handling factors
  - Attaining and retaining maximum quality
Case study:
Perception of melon quality

- Overall consumer acceptance (and repeat buy) strongly correlated with “Flavor acceptance”

![Graph showing correlations]

Effect of Maturity and Ripeness on Selected Sensory Attributes

Mean Sensory Score

- "Sweet" taste
- Soluble Solids Content

![Graph showing mean sensory scores]

Early mature

Fully ripe

- Early mature
- Fully ripe
Fruit Volatile Analysis Using an Electronic Nose

Nondestructive Quality Sensing Needs

- Degree of freshness (time since harvest)
- Prior exposure to ethylene (concentration x duration x temperature)
- Prior exposure of chilling-sensitive commodities to chilling conditions (temperature x duration)
- Internal translucency / browning
- Mealiness (lack of juiciness)
- Acidity / nutritional value
- Aroma (volatiles)

Questions?